

*HYMENOXYS JAMESII* (ASTERACEAE: HELIANTHEAE):  
A NEW SPECIES FROM ARIZONA

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ABSTRACT

*Hymenoxys jamesii* is a new species endemic to the Mogollon Plateau of Arizona. Morphologic, cytologic, and chemical data are all consistent with its recognition as a species in *Hymenoxys* subgenus *Picradenia*, where it appears to be most similar to the more widespread *H. cooperi*.

RESUMEN

Se describe una nueva especie endémica, *Hymenoxys jamesii*, del Altiplano Mogollon de Arizona. Datos morfológicos, citológicos y químicos son consistentes con reconocimiento de este taxón como una especie de *Hymenoxys* subgénero *Picradenia*, adonde se parece mas a *H. cooperi*, un taxón de ambito geographico amplio.

For several years I have collected plants of the genus *Hymenoxys* on the Mogollon Plateau of eastern central Arizona. It appeared that these plants were closely related to but distinct from plants classified as *Hymenoxys cooperi* (A. Gray) Cockerell; however, caution was warranted until type studies could be done because *H. cooperi* is widespread and morphologically very variable and several variants had already been described as species or varieties. Now that I have completed type, morphologic, and cytologic studies, I am confident that this entity has not been described previously and that it should be recognized as a species in *Hymenoxys* subgenus *Picradenia*.

MATERIALS AND METHODS

Type specimens were borrowed from BM, F, GH, K, MICH, MO, NDG, PH, RM, NY, UC, and US.

For morphologic studies, representative specimens from throughout the ranges of *Hymenoxys jamesii* and *H. cooperi* (see Fig. 1) were examined for descriptive purposes and for counts and measurements dealing with plant height, stem number, midstem leaf width, peduncle length, head number, height, and diameter, and receptacle height and diameter. For counts and measurements dealing with outer and inner involucral bract number, length, and width, ligule number, length, and width, disc corolla length and diameter, disc corolla tube length, achene length and diameter, pappus scale number, length, and width, and pappus scale awn length, nine spec-

imens of *H. jamesii* and 11 specimens of *H. cooperi* (each from a different population) from throughout the range of each taxon were selected, and one or two flowering heads were removed from each for examination. The heads were dissected after they had soaked in detergent water, and all parts except for the ligules were allowed to dry before any measurements were made. From each head, all of the involucre bracts and ligules were counted and measured, ten disc corollas were selected for measurements, ten achenes were selected for measurements and for pappus scale counts, and one pappus scale from each achene was selected for measurements. Counts and measurements are presented in the description as the mean plus or minus one standard deviation followed by the range (given as minimum to maximum) and sample size (n). Characters from the different taxa were compared using the unpaired, two-tail t-test (Table 1). Because separate t-tests were run on multiple characters, a difference is not considered to be statistically significant unless  $P \leq 0.01$ . All statistical work was done with StatView<sup>™</sup> 512+ (Abacus Concepts, 1986) on a Macintosh II computer.

For cytologic studies, bud material was fixed in a modified Carnoy's solution: chloroform, absolute ethanol, and glacial acetic acid (4:3:1; V:V:V). Chromosomes were stained with acetocarmine, and counts were obtained from microsporocytes at metaphase I. The voucher specimen is deposited at TEX.

## RESULTS AND DISCUSSION

Taxa included in *Hymenoxys* subgenus *Picradenia* are biennials or perennials of North America. They have involucre bracts that are arranged in two morphologically distinct series; the inner bracts are free, and the outer bracts are united for some portion of their length. As recognized here, subgenus *Picradenia* contains 11 taxa: *H. brachyactis* Wooton & Standley, *H. cooperi* (A. Gray) Cockerell, *H. helenioides* (Rydb.) Cockerell, *H. jamesii* Bierner, *H. lemmonii* (E. Greene) Cockerell, *H. quinquesquamata* Rydb., *H. richardsonii* (Hook.) Cockerell var. *richardsonii*, *H. richardsonii* var. *floribunda* (A. Gray) K. Parker, *H. rusbyi* (A. Gray) Cockerell, *H. subintegra* Cockerell, and *H. vaseyi* (A. Gray) Cockerell. Other taxa commonly included in *Hymenoxys* are here recognized as belonging to other subgenera of *Hymenoxys* or to separate genera.

All original descriptions and type specimens referable to *Hymenoxys* subgenus *Picradenia* were examined, and none of them matched the Arizona plants treated here as *Hymenoxys jamesii*. Furthermore, I am now of the opinion that *H. cooperi* is but one taxon and that the following names (along with their associated nomenclatural synonyms) should be treated as taxonomically synonymous with *H. cooperi*: *Actinella richardsonii* (Hook.) Nutt. var. *canescens* D. Eaton

TABLE 1. COMPARISON OF *HYMENOXYLS JAMESII* AND *H. COOPERI*. For characters compared by t-test, the unpaired t value (t) and two-tail probability (P) are shown following the character. Counts and measurements are presented as the mean plus or minus one standard deviation followed by the sample size (n).

Character	Characteristic	
	<i>H. jamesii</i>	<i>H. cooperi</i>
Flowering date	summer	spring
Habit	apparently biennial	apparently biennial
Plant height (t = 2.56; P = 0.0141)	6.0 ± 1.7 dm (n = 28)	4.8 ± 1.4 dm (n = 18)
Number of stems from the base	usually 1	usually 1
Stem branching pattern	paniculate to corymbose	paniculate to corymbose
Stem pubescence	sparse to dense	sparse to dense
Stem coloration	usually purple-red below	usually purple-red below
Basal leaf segment number	(3-5)-7(-9)	3-5(-7)
Basal leaf pubescence	usually sparse	moderate to dense
Lower leaf segment number	3-5(-7)	3-5(-7-9)
Lower leaf pubescence	sparse to moderate	sparse to usually moderate
Middle leaf segment number	3-5	3-5
Middle leaf pubescence	sparse to dense	sparse to dense
Upper leaf segment number	1-3(-5)	1-3
Upper leaf pubescence	sparse to dense	sparse to moderate
Midstem leaf width (t = -2.26; P = 0.0262)	1.4 ± 0.3 mm (n = 61)	1.6 ± 0.4 mm (n = 25)
Peduncle apex pubescence	moderate to dense	moderate to dense
Peduncle length (t = -9.23; P = 0.0001)	2.6 ± 1.0 cm (n = 56)	5.6 ± 2.1 cm (n = 44)
Head number (t = 5.38; P = 0.0001)	114 ± 65 per plant (n = 28)	25 ± 18 per plant (n = 16)
Head shape	subhemispheric to campanulate	subhemispheric to hemispheric
Head height (t = -19.72; P = 0.0001)	5.9 ± 0.7 mm (n = 59)	9.1 ± 0.8 mm (n = 37)
Head diameter (t = -23.94; P = 0.0001)	6.4 ± 1.0 mm (n = 59)	12.8 ± 1.6 mm (n = 37)
Receptacle shape	hemispheric to usually conic	hemispheric to usually conic
Receptacle height (t = -8.28; P = 0.0001)	1.3 ± 0.3 mm (n = 20)	2.3 ± 0.4 mm (n = 20)
Receptacle diameter (t = -11.642; P = 0.0001)	1.7 ± 0.4 mm (n = 20)	3.8 ± 0.7 mm (n = 20)
Outer bract number (t = -7.45; P = 0.0001)	8 ± 1 per head (n = 18)	12 ± 2 per head (n = 11)

TABLE 1. CONTINUED.

Character	Characteristic	
	<i>H. jamesii</i>	<i>H. cooperi</i>
Outer bract shape		lanceolate
Outer bract outer surface pubescence		sparse to dense
Outer bract length ( $t = -26.47$ ; $P = 0.0001$ )	ovate to lanceolate	$6.6 \pm 1.0$ mm ( $n = 135$ )
Outer bract width ( $t = -12.87$ ; $P = 0.0001$ )	sparse to moderate	$1.8 \pm 0.4$ mm ( $n = 136$ )
Inner bract number ( $t = -7.91$ ; $P = 0.0001$ )	$3.5 \pm 0.5$ mm ( $n = 86$ )	$17 \pm 3$ ( $n = 11$ )
Inner bract shape	$1.2 \pm 0.3$ mm ( $n = 86$ )	obovate to narrowly obovate
Inner bract outer surface pubescence	$10 \pm 2$ ( $n = 18$ )	sparse to moderate
Inner bract length ( $t = -31.26$ ; $P = 0.0001$ )	obovate	$5.4 \pm 0.6$ mm ( $n = 184$ )
Inner bract width ( $t = -12.31$ ; $P = 0.0001$ )	glabrous to moderate	$2.1 \pm 0.4$ mm ( $n = 184$ )
Ray floret number ( $t = -9.40$ ; $P = 0.0001$ )	$3.4 \pm 0.4$ mm ( $n = 111$ )	$12 \pm 2$ ( $n = 11$ )
Ligule upper surface pubescence	$1.6 \pm 0.3$ mm ( $n = 111$ )	glabrous
Ligule lower surface pubescence	$8 \pm 1$ ( $n = 18$ )	sparse
Ligule length ( $t = -35.09$ ; $P = 0.0001$ )	glabrous to dense	$14.3 \pm 2.5$ mm ( $n = 128$ )
Ligule width ( $t = -23.46$ ; $P = 0.0001$ )	$2.6 \pm 0.2$ mm ( $n = 90$ )	$6.1 \pm 1.3$ mm ( $n = 128$ )
Disc corolla pubescence	$0.5 \pm 0.1$ mm ( $n = 90$ )	moderate
Disc corolla length ( $t = -18.14$ ; $P = 0.0001$ )	$0.7 \pm 0.1$ mm ( $n = 90$ )	$3.6 \pm 0.5$ mm ( $n = 110$ )
Disc corolla diameter ( $t = -3.91$ ; $P = 0.0001$ )	narrowly obconic	$0.6 \pm 0.1$ mm ( $n = 110$ )
Disc corolla tube length ( $t = -14.2$ ; $P = 0.0001$ )	dense	$1.1 \pm 0.2$ mm ( $n = 110$ )
Achene shape	narrowly obconic	narrowly obconic
Achene pubescence	dense	dense
Achene length ( $t = -14.88$ ; $P = 0.0001$ )	$1.9 \pm 0.1$ mm ( $n = 90$ )	$2.6 \pm 0.5$ mm ( $n = 110$ )
Achene diameter ( $t = -14.17$ ; $P = 0.0001$ )	$0.5 \pm 0.1$ mm ( $n = 90$ )	$0.8 \pm 0.2$ mm ( $n = 110$ )
Pappus scale number ( $t = -3.79$ ; $P = 0.0002$ )	usually 5 per achene ( $n = 115$ )	$5 \pm 1$ per achene ( $n = 110$ )
Pappus scale shape	obovate	obovate
Pappus scale length ( $t = -23.02$ ; $P = 0.0001$ )	$1.3 \pm 0.3$ mm ( $n = 115$ )	$2.6 \pm 0.4$ mm ( $n = 110$ )
Pappus scale width ( $t = -9.63$ ; $P = 0.0001$ )	$0.8 \pm 0.1$ mm ( $n = 115$ )	$1.0 \pm 0.2$ mm ( $n = 110$ )
Pappus awn length ( $t = -6.89$ ; $P = 0.0001$ )	$0.2 \pm 0.1$ mm ( $n = 26$ )	$0.4 \pm 0.1$ mm ( $n = 75$ )

in S. Watson, *Actinella biennis* A. Gray, *Hymenoxys canescens* (D. Eaton) Cockerell var. *nevadensis* Cockerell, *Hymenoxys cooperi* (A. Gray) Cockerell var. *argyrea* Cockerell, and *Hymenoxys virgata* Nelson.

*Hymenoxys jamesii* differs from *H. cooperi* in many of its characters (Table 1). Most notably, the two taxa differ with regard to flowering date, and they are statistically significantly different from one another in peduncle length, number of heads per plant, head height and diameter, receptacle height and diameter, outer and inner bract number, length, and width, ray floret number, ligule length and width, disc corolla length and diameter, disc corolla tube length, achene length and diameter, pappus scale number, length, and width, and pappus awn length. Of these, the most useful characters for diagnostic purposes are flowering date, number of heads per plant, head height and diameter, outer and inner bract number, ray floret number, and ligule length and width.

Conversely, *Hymenoxys jamesii* and *H. cooperi* are very similar with regard to habit, stem and leaf characteristics, ligule pubescence, achene shape and pubescence, and pappus scale shape (Table 1).

*Hymenoxys cooperi* and several other taxa in *Hymenoxys* subgenus *Picradenia* (*H. helenioides*, *H. quinquesquamata*, *H. richardsonii* var. *richardsonii* and *H. richardsonii* var. *floribunda*, *H. rusbyi*, *H. subintegra*, and *H. vaseyi*) have all been reported to have chromosome numbers of  $n=15$  (Speese and Baldwin 1952; Strother 1966; Kovanda 1972; Watson 1973; Keil & Stuessy 1975; Hartman 1977). The only suggestion of dysploidy in subgenus *Picradenia* comes from one report of  $n=14$  for *H. richardsonii* (presumably var. *richardsonii*) from Canada (Taylor & Brockman 1966). *Hymenoxys jamesii* is here reported to have  $2n=15_{II}$  (*Bierner 91-88*, see list of specimens examined).

*Hymenoxys cooperi* (as *H. biennis*) has been reported by Gao et al. (1990) to produce (among other compounds) sesquiterpene lactones very similar or identical to ones produced by other taxa in *Hymenoxys* subgenus *Picradenia* (e.g., Sanderson 1975; Seaman 1982). Recent unpublished work by Otmar Spring and Barbara Zitterell-Haid (personal communication) appears to confirm a high degree of similarity among the taxa of *Hymenoxys* subgenus *Picradenia* (including *H. jamesii*) with regard to sesquiterpene lactone content. Of note, their data suggest that *H. jamesii* may be chemically more similar to *H. subintegra*, a taxon restricted to the Kaibab Plateau of northern Arizona, than to *H. cooperi*.

Morphologic, cytologic, and chemical data are all consistent with the placement of *Hymenoxys jamesii* in *Hymenoxys* subgenus *Picradenia*. It is here recognized as a distinct species because it is completely allopatric to and morphologically distinct from the other taxa of *Hymenoxys*.

**Hymenoxys jamesii** Bierner, sp. nov.—TYPE: USA, Arizona, Navajo Co.: forest rd 504 (rd to Winslow from Heber), 5.9 mi NW of hwy 260 (jct just W of Heber), 12 Aug 1991, *Bierner 91-87* (holotype, TEX; isotypes, NY, US).

*H. cooperi* (A. Gray) Cockerell affinis sed capitulis parvioribus numerosioribusque, ligulis parvioribus paucioribusque, et pappi squamis brevioribus notabilis.

Plants apparently biennial,  $6.0 \pm 1.7$  dm tall (range 3.5–11.4 dm;  $n = 28$ ) excluding the root. Stems usually 1, but sometimes 2–4 or rarely as many as 15–20, paniculately to corymbosely branched above, sulcate below becoming striate above, usually distinctly purple-red below becoming green above, usually moderately to densely pubescent below becoming sparsely to moderately pubescent above, but ranging from sparsely to densely pubescent throughout. Leaves dotted with impressed glands, entire, simple to pinnately or bipinnately divided into 3–9 linear segments, terminal segment of mid-stem leaves  $1.4 \pm 0.3$  mm wide (range 0.8–2.2 mm;  $n = 61$ ); basal leaves in a dense rosette, usually divided into 5–7 segments, but sometimes with as few as 3 or as many as 9 segments, usually sparsely pubescent; lower leaves usually divided into 3–5 segments, but sometimes with 7 segments, sparsely to moderately pubescent; middle leaves divided into 3–5 segments, sparsely to densely pubescent; upper leaves simple or divided into 3(–5) segments, sparsely to densely pubescent. Peduncles  $2.6 \pm 1.0$  cm long (range 1.3–5.0 cm;  $n = 56$ ), striate, expanded apically, sparsely to densely pubescent below becoming moderately to densely pubescent above, sparsely to moderately dotted with sessile glands below, becoming moderately to densely dotted with sessile glands above. Heads  $114 \pm 65$  per plant (range 30–330;  $n = 28$ ), subhemispheric to campanulate,  $5.9 \pm 0.7$  mm high (range 4–7 mm;  $n = 59$ ),  $6.4 \pm 1.0$  mm in diameter (range 4–8 mm;  $n = 59$ ) excluding the rays. Receptacle hemispheric to, usually, conic, naked,  $1.3 \pm 0.3$  mm high (range 1.0–2.0 mm;  $n = 20$ ),  $1.7 \pm 0.4$  mm in diameter (range 1.0–2.4 mm;  $n = 20$ ). Involucral bracts in two morphologically distinct series; outer bracts usually 8 or 9 per head (range 8–10;  $n = 18$ ), united their lower one-third, green and herbaceous, keeled, ovate to lanceolate, apex acute to acuminate, outer surface sparsely to moderately pubescent, particularly along the margins, and sparsely to densely dotted with sessile and(or) impressed glands, inner surface glabrous or sometimes sparsely pubescent at the apex,  $3.5 \pm 0.5$  mm long (range 2.9–5.5 mm;  $n = 86$ ),  $1.2 \pm 0.3$  mm wide (range 0.5–1.9 mm;  $n = 86$ ); inner bracts usually  $10 \pm 2$  per head (range 8–14;  $n = 18$ ), free, usually slightly exceeding the outer bracts due to their higher point of attachment, body yellow and scale-like, tip yellow-green to green and herbaceous, weakly keeled, obovate, mucronate, outer surface

glabrous to moderately pubescent, particularly along the margins, and sparsely to moderately dotted with sessile glands, inner surface glabrous,  $3.4 \pm 0.4$  mm long (range 2.8–4.2 mm;  $n = 111$ ),  $1.6 \pm 0.3$  mm wide (range 1.0–2.5 mm;  $n = 111$ ). Ray florets carpellate, fertile, usually 8 per head (range 7–9;  $n = 18$ ); ligules yellow, 3-lobed, tube glabrous to sparsely pubescent, upper surface glabrous and eglandular, lower surface sparsely pubescent and sparsely to moderately dotted with sessile glands,  $6.5 \pm 0.9$  mm long (range 4.2–8.0 mm;  $n = 142$ ),  $3.3 \pm 0.6$  mm wide (range 2.3–5.0 mm;  $n = 141$ ). Disc florets hermaphroditic, fertile; corollas yellow with yellow lobes, 5-lobed, the lower one-fourth to one-third usually constricted into a narrower yellow-brown tube, cylindrical to cylindrical campanulate, glabrous to densely pubescent and sparsely to moderately dotted with sessile glands,  $2.6 \pm 0.2$  mm long (range 2.4–3.0 mm;  $n = 90$ ),  $0.5 \pm 0.1$  mm in diameter (range 0.4–0.8 mm;  $n = 90$ ), the tube  $0.7 \pm 0.1$  mm long (range 0.6–0.9 mm;  $n = 90$ ). Achenes narrowly obconic, densely pubescent with straight, forked, antrorse hairs,  $1.9 \pm 0.1$  mm long (range 1.6–2.1 mm;  $n = 90$ ),  $0.5 \pm 0.1$  mm in diameter (range 0.4–0.7 mm;  $n = 90$ ). Pappus scales usually 5 (range 4–8;  $n = 115$ ), obovate, apex rounded to obtuse to, usually, acuminate into an acute point or short awn,  $1.3 \pm 0.3$  mm long (range 0.8–2.1 mm;  $n = 115$ ) including the awn if present,  $0.8 \pm 0.1$  mm wide (range 0.5–1.0 mm;  $n = 115$ ), the awn when present  $0.2 \pm 0.1$  mm long (range 0.1–0.4 mm;  $n = 26$ ). Chromosome number:  $2n=15_{II}$ .

Distributed on the Mogollon Plateau of eastern central Arizona (Fig. 1). Flowering mainly in July and August.

*Specimens examined.* USA, ARIZONA, Coconino Co.: Blueridge Ranger Station, Coconino Forest, 7 Aug 1929, *Eggleston 23381* (LL); Sitgraves National Forest, Mogollon Rim, off hwy 160, 18 Aug 1970, *Correll & Correll 39422* (LL); hwy 87, 10.9 mi SW of turnoff to Happy Jack and Flagstaff, 9 Aug 1975, *Bierner 51384* (TEX); hwy 87, 7.7 mi SW of turnoff to Happy Jack, 30 Jul 1988, *Bierner 88-72* (TEX); forest rd 504 (rd to Heber), 2.9 mi S of hwy 99, 11 Aug 1991, *Bierner 91-84* (TEX). Gila Co.: 3 mi S of Pine along hwy 87, 19 Jul 1973, *Higgins 7849* (NY); hwy 87, 13.0 mi NW of hwy 260, just S of Pine, 9 Aug 1975, *Bierner 51382* (TEX); hwy 87, 14.1 mi NW of hwy 260, just S of Pine, 9 Aug 1975, *Bierner 51383* (TEX). Navajo Co.: Chevelon Crossing Campground, ca. 16 mi NW of hwy 260 on forest rd 504 (jct just W of Heber), 11 Aug 1991, *Bierner 91-85* (TEX); forest rd 504 (rd to Winslow from Heber), 11.5 mi NW of hwy 260 (jct just W of Heber), 12 Aug 1991, *Bierner 91-86* (TEX); forest rd 504 (rd to Winslow from Heber), 1.4 mi NW of hwy 260 (jct just W of Heber), chromosome number  $2n=15_{II}$ , 12 Aug 1991, *Bierner 91-88* (TEX).

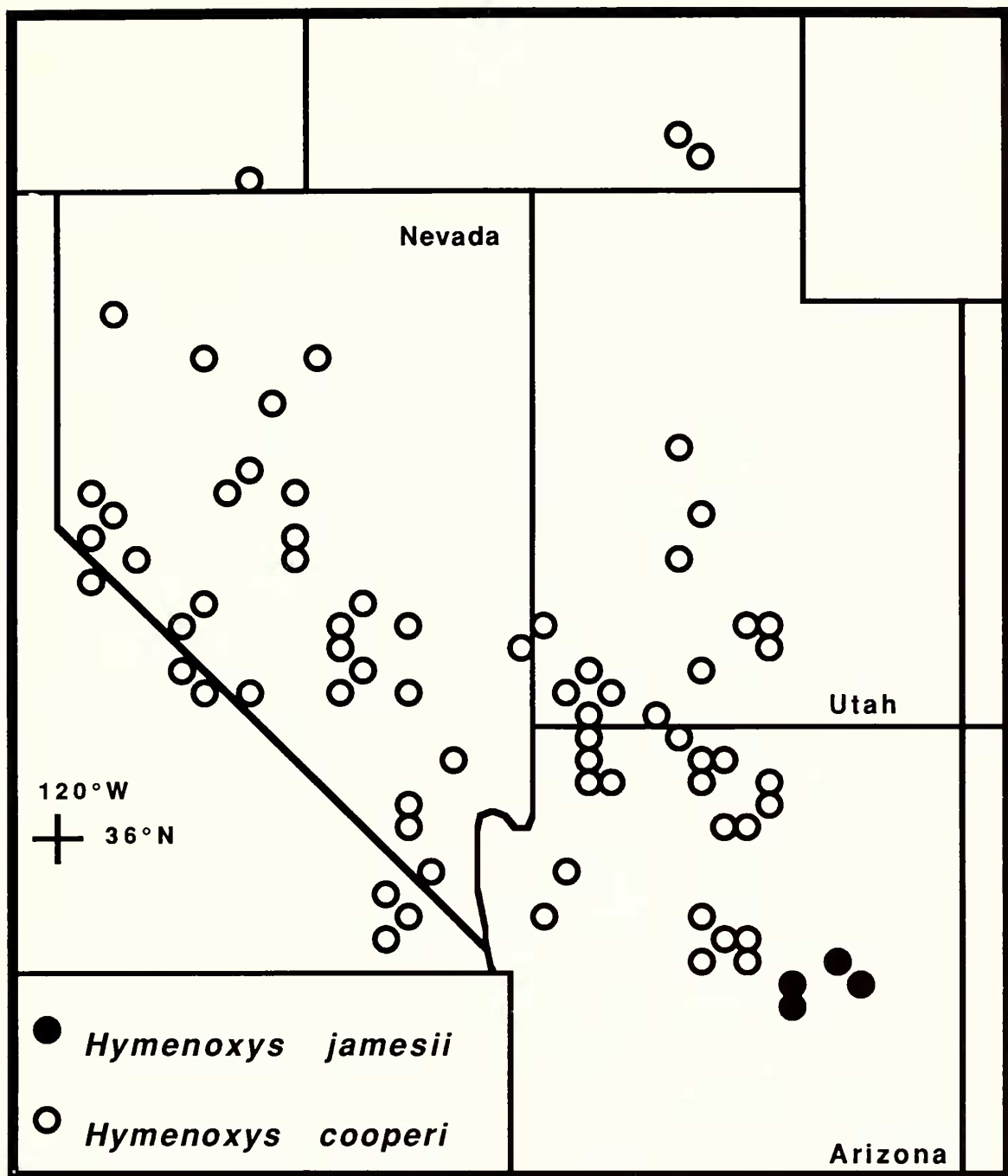


FIG. 1. Distribution of *Hymenoxys jamesii* and *H. cooperi*.

#### ACKNOWLEDGMENTS

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